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ORIGINAL CONTRIBUTIONS

Fresh Whole Blood Transfusions in Coalition Military, Foreign National, and Enemy Combatant Patients during Operation Iraqi Freedom at a U.S. Combat Support Hospital

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Abstract
Background United States military doctrine permits the use of fresh whole blood (FWB), donated by U.S. military personnel on site, for casualties with life-threatening injuries at combat support hospitals. U.S. Military Medical Department policy dictates that all patients treated at military facilities during combat (coalition military personnel, foreign nationals, and enemy combatants) are to be treated equally. The objectives of this study were to describe admission vital signs and laboratory values and injury location for patients transfused with FWB, and to determine if FWB was employed equally among all patient personnel categories at a combat support hospital.
Methods This retrospective cohort study evaluated admission vital signs and laboratory values, injury location, and personnel category for all patients receiving FWB at a U.S. Army combat support hospital in Baghdad, Iraq, between January and December 2004.
Results Eighty-seven patients received 545 units of FWB. Upon admission, the average (±S.D.) heart rate was 144 bpm (±25); systolic blood pressure, 106 mmHg (±33); base deficit, 9 (±6.5); hemoglobin, 9.0 g/dl (±2.6); platelet concentration, $81.9 \times 10^3/mm^3$ (±81); international normalized ratio (INR), 2.0 (±1.1); and temperature 95.7°F (±2.6). The percentages of intensive care patients who received FWB by personnel category were as follows: coalition soldiers, 51/592 (8.6%); foreign nationals, 25/347 (7.2%); and enemy combatants, 11/128 (8.5% ($p = 0.38$). The amount of FWB transfused by personnel category was as follows: coalition soldier, 4 units (1–35); foreign national, 4 units (1–36); and enemy combatant, 4 units (1–11) ($p = 0.9$).
Conclusions Fresh whole blood was used for anemic, acidemic, hypothermic, coagulopathic patients with life-threatening traumatic injuries in hemorrhagic shock, and it was transfused in equal percentages and amounts for coalition soldiers, foreign nationals, and enemy combatants.

The views and opinions expressed in this manuscript are those of the authors and do not reflect the official policy or position of the Army Medical Department, Department of the Army, the Department of Defense, or the United States Government.

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Fresh whole blood (FWB) has been used to resuscitate patients with combat-related injuries since World War I [1]. Military doctrine states that the use of FWB is acceptable when standard blood components are not available for life-saving therapy [2]. Previous reports have detailed the process of developing a FWB transfusion program and the rationale

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for its use [3–5]. Recently, the risks and benefits of FWB compared to the use of stored components for critically ill patients have been reviewed [6].

Fresh whole blood is defined by the U.S. Military Medical Department as whole blood that is kept at room temperature and transfused within 24 h of collection [2]. Our practice was to transfuse FWB immediately after it was collected. Under optimal conditions, with available lab personnel and immediate access to donors, the time from initiating the call for FWB to transfusion was approximately 25 min.

The decision to initiate the collection and administration of FWB to a casualty with life-threatening injuries is a clinical decision made by providers at military facilities. U.S. military medical doctrine states that equal medical care will be rendered for all casualties regardless of personnel status [2]. This policy includes the transfusion of FWB. Our objective in this report was to provide a descriptive analysis of the patients who received FWB and to compare the use of FWB transfusion among coalition military, foreign national, and enemy combatant patients treated at one combat support hospital (CSH) between January and December 2004.

Methods

This retrospective protocol received internal review board (IRB) approval through the Department of Clinical Investigation at Brooke Army Medical Center, San Antonio, TX. The Joint Theater Trauma Registry (JTTR) is a trauma database established by the Department of Defense to capture data from non-integrated clinical and administrative systems to provide comprehensive information describing trauma care from point of injury through hospital transfer or discharge for all casualties admitted to military medical facilities. In this study, the JTTR was reviewed for all patients who received a FWB transfusion at the CSH in Baghdad between January and December 2004. After the patients were identified, their charts were evaluated for admission vital signs and laboratory values, personnel status, total number blood products administered, and injury severity score (ISS). Personnel categories for patients included coalition soldiers (U.S. and foreign military personnel), foreign nationals (civilians and contract workers), and enemy combatants. Personnel categories were determined by hospital personnel administration and hospital military police staff.

Donors for FWB transfusion consisted of hospital staff, and military and Department of Defense (DoD) personnel stationed near the CSH. Within the CSH in Baghdad, FWB donors were screened for eligibility with a standard questionnaire and for anemia with copper sulfate testing prior to donation. During the collection process a donor sample was typed and cross matched to the recipient and was rapidly tested (15–20 min) with an immunochromatographic test (Biokit, Spain) for human immunodeficiency virus types ½ (HIV) and hepatitis B and C. After testing was completed, the FWB that was collected into a CPDA bag was transfused warm immediately into the casualty. Standard blood administration tubing was used without leukopore filters to rapidly administer transfusions to these severely injured casualties.

Injuries were coded using the 1998 version of the Abbreviated Injury Scale. The ISS was calculated by trained staff at the U.S. Army Institute of Surgical Research according to the methods described by the Association for the Advancement of Automotive Medicine (AAAM) Abbreviated Injury Scale, 1998 Revision [7]. Data are presented as median (range) or mean (± the standard deviation). Student's *t*-test and the Kruskal-Wallis, Wilcoxon rank-sum, and chi-square tests were used for statistical comparisons, as appropriate. Statistical analysis was performed by one of the authors (P.C.S.) with SPSS 14.0 (Chicago, IL).

Results

Descriptive Analysis of FWB Recipients

From 1 January 1 to 26 December 2004, 3,287 patients with traumatic injuries were admitted to the CSH in Baghdad, Iraq. During this period 5,294 units of red blood cell (RBC) transfusions were given to 923/3,287 (28%) patients, and 545 units of FWB were transfused to 87/3,287 (3%) patients. The majority of patients who received FWB 84/87 (97%) also received RBCs. Fresh whole blood recipients were 84/87 (97%) male with a mean age of 27 (±8) years. The median (range) ISS for all patients receiving FWB was 21 (4–50). All patients who received FWB received a median (range) of 4 units (1–36) of FWB, 13 units (0–47) of RBCs, 8 units (0–48) of FFP, and 5 units (0–30) of cryoprecipitate.

The distribution of blood types among the 87 FWB recipients was O+/O– (52%/5%), A+/A– (29%/4%), B+/B– (5%/1%), AB+/AB– (4%/0%), which is similar to the frequency of these blood types measured in a random population in the United States [8]. Vital signs upon admission to the CSH for FWB recipients were mean (±S.D.) heart rate of 144 bpm (±25), systolic blood pressure 106 mmHg (±33), and body temperature 95.7°F (±2.6). Laboratory results upon admission revealed that patients who received FWB were mean (±S.D.) haemoglobin, 9.0 g/dl (±2.6); platelet concentration, $81.9 \times 10^3/mm^3$ (±81); INR, 2.0 (±1.1); and base deficit, 9 (±6.5).

Differences were observed in FWB use dependent on injury location. Extremity, face and neck, and abdominal injuries were the most frequent injury locations for all ICU patients. Patients with extremity and abdominal injuries received most of the FWB units: 179/545 units (33%), and 159/545 units (29%), respectively (Table 1). By injury location, 7/53 patients with pelvic injuries (13%) were the most likely to receive FWB transfusions. Statistically, patients with pelvic, brain, thoracic, and abdominal injuries received a higher percentage of FWB transfusions than patients with extremity, face/neck, and spine injuries ($p = .01$; Table 1). The mean ISS by injury location was not different when compared between all categories ($p = .51$; Table 1).

Utilization of FWB Transfusion by Personnel Category

ISS-98 values were similar for coalition soldiers 22 (4–50), foreign nationals 25 (9–50), and enemy combatants 17.5 (9–42) ($p = 0.63$). There were no significant differences in the percentage of intensive care patients who received FWB when the 51/592 coalition soldiers (8.6%), the 25/347 foreign nationals (7.2%), and the 11/128 enemy combatants (8.5%) were compared ($p = 0.38$). Equal amounts of FWB were transfused to all patients; 4 units (1–35) to coalition soldiers, 4 units (1–36) to foreign nationals, and 4 units (1–11) to enemy combatants ($p = 0.9$).

Discussion

This detailed descriptive report of FWB use for combat-related casualties is, to our knowledge, the largest in the literature. Our results indicate that FWB was transfused to patients in hemorrhagic shock with life-threatening injuries. Additionally, this FWB which was collected at the CSH from U.S. Military and Department of Defense personnel, was distributed equally and in identical amounts to coalition soldiers, foreign nationals, and enemy combatants with similar severity of injury.

The transfusion of FWB to treat patients with hemorrhagic shock has been documented from WWI to the current conflicts in Afghanistan and Iraq [1, 9]. Our description of the patients who received FWB at the Baghdad CSH supports military doctrine, which states that FWB should only be transfused to patients with life-threatening injuries. Patients who received FWB upon admission were tachycardic with low blood pressure and were hypothermic, acidemic, anemic, thrombocytopenic, or coagulopathic. Previous reports have indicated that each and these factors in patients with traumatic injuries has been associated with mortality [10–17].

The rationale for FWB use in combat has been described elsewhere [3, 5]. Current U.S. Army clinical practice guidelines state that FWB is appropriate for combat-related casualties if there is life-threatening injury and if any blood component (RBCs, plasma, platelets) is indicated for treatment and not available, or if the transfusion of available blood components in a 1:1:1 ratio with adequate surgical control does not effectively reduce life-threatening bleeding. These guidelines also state that at a CSH the FWB should be typed and crossed to the recipient, and rapid infectious disease screening of donor FWB is to be performed prior to its transfusion to the recipient.

The approach of utilizing FWB, for patients with the coagulopathy of trauma [18–20] when the patients' coagulopathy is not responding to the use of blood components in a 1:1:1 ratio is consistent with the concept of damage control resuscitation [13, 14, 21–23]. Damage control resuscitation is indicated for patients with life-threatening injuries and the coagulopathy of trauma. It requires immediate surgical

Table 1 Distribution of FWB transfusions in ICU patients according to location of injury

Injury location	Injury severity score-98[a]	Percentage of ICU patients who received FWB[b]	Median (range) of FWB units transfused[c]	Percentage of FWB units transfused
Pelvis	23.1 (±15.6)	7/53 (13%)[x]	4 (2–21)	52/545 (9.5%)
Thorax	37.5 (±27)	13/158 (8%)[x]	2 (1–9)	46/545 (8.4%)
Brain	32.5 (±22.5)	13/164 (8%)[x]	2 (1–5)	31/545 (5.7%)
Abdomen	25.1 (±15)	19/271 (7%)[x]	5 (2–35)	159/ 545 (29%)
Extremity	25.9 (±16.6)	24/628 (4%)[y]	4.5 (1–25)	179/ 545 (33%)
Spine	13	1/30 (3%)[y]	2	2/545 (0.4%)
Face/neck	23 (±5.5)	4/364 (1%)[y]	4 (2–5)	15/545 (2.8%)
Unknown	23 (±8.5)		5 (1–36)	61/545 (11.2%)

[a] No difference of ISS-98 between all injury locations (p = .51), analysis of variance (ANOVA).

[b] Number of FWB recipients/total number of ICU patients (percentage). NOTE: Percentage of FWB transfused to x > y ($p = .01$); chi-square test.

[c] Median FWB units transfused per patient (range of units transfused).

control of bleeding with the rapid correction of coagulopathy which can be accomplished with the use of RBCs, plasma, and platelets in a 1:1:1 ratio, the early use of other pro-hemostatic agents (cryoprecipitate and rFVIIa), avoidance of dilutional coagulopathy by the overuse of crystalloid and RBCs, and the prevention or treatment of acidosis and hypothermia. Recent studies have documented improved survival when damage control resuscitation strategies have been practiced [24, 25]. Fresh whole blood provides a more concentrated and effective product that can improve coagulation and oxygen delivery for patients with life-threatening hemorrhagic shock more effectively than reconstituted whole blood from stored components [6, 26]. Further study is needed to determine if the use of FWB for the resuscitation of traumatic injuries during combat improves outcomes. Interestingly, the treatment or correction of anemia with stored RBC transfusion, acidemia with bicarbonate solutions, and the pre-hospital treatment of hypotension with crystalloid infusions have not been associated with improving survival in patients with traumatic injuries [6, 15, 27–33].

Pelvic injuries represented the highest percentage of ICU patients who received FWB. Statistically, ICU patients with pelvic, brain, thoracic, and abdominal injuries required FWB more frequently than patients with injuries at other locations. We suspect that this was most likely due to the coagulopathy and difficulty of surgically controlling bleeding of injuries in these locations. Patients with extremity injuries and abdominal wounds received the majority of FWB units, largely because these were the most frequent injuries in patients admitted to the ICU at the CSH. Descriptive reports such as this can potentially help in the development of guidelines that will identify those patients most likely to require FWB transfusion.

Changes to FWB transfusion programs conducted at some CSHs since January 2006 include standard infectious disease testing (human immunodeficiency virus [HIV], hepatitis C virus [HCV], hepatitis B virus [HBV], rapid plasma regain [RPR] titer, and human T-cell lymphotropic virus) of donor samples to determine donor eligibility. This is accomplished by sending samples from potential donors back to the United States prior to the call for FWB donation. In addition to the infectious agent testing performed in the United States, all donors at CSHs are tested again immediately prior to donation with the rapid tests for HIV, HCV, HBV, and (now available) RPR (Biokit, Spain). At medical facilities smaller than CSHs and in more remote locations, it is often not possible to accomplish routine typing and crossmatching of donor FWB to potential recipients or to perform rapid infectious disease screening. Furthermore, FWB should only be transfused for patients with life-threatening injuries. The risks of FWB transfusion should always be balanced with the risk of mortality without its use.

A limitation of the present study was that we were not able to measure the effect of FWB on survival. This is a result of there not being enough patients included in this report to adequately assess the effect of FWB on survival. Future studies will report on the effect of FWB on survival in combat-related casualties.

Documentation of the management and treatment of enemy combatants has been described in all of the major conflicts involving the U.S. military to include World War II, the Korean Conflict, and the Vietnam War. Data from Operation Desert Storm generated concern regarding medical care for enemy combatants [34, 35]. During Operation Iraqi Freedom the ethical treatment of enemy combatants has been questioned by the media and in the medical literature [36–38]. Conversely, other studies have documented the appropriate provision of pharmaceutical services to enemy combatants [39–41]. In this report we note that the use of FWB donated at the CSH by U.S. soldiers and DoD personnel was transfused equally across all personnel categories. Our data indicate that the active decision to collect and transfuse for FWB was based on the severity of the patient's injury and was not influenced by personnel status.

The first Geneva Convention was signed in 1864 to protect the sick and wounded during war time. In 1929, two more Geneva Conventions dealt with the treatment of the wounded and prisoners of war. Article 30 of Convention III states: "Every camp shall have an adequate infirmary where prisoners of war may have the attention they require" [42]. Current U.S. Military Medical Department policy is based on United Nations General Assembly Resolution 37/194 of 18 December 1982, which states that enemy combatants are to receive care that is equal to that of all other patients [2]. The rationale for this approach is that all patients regardless of personnel category deserve equal treatment and to do otherwise would be unethical. Despite this policy, the use of our own blood to resuscitate enemy combatants to many civilian medical personnel has been considered extraordinary.

This report provides a framework for a FWB transfusion program that civilian hospitals could use to augment a massive transfusion protocol for a large number of casualties if stored component blood products are exhausted [43]. In addition, our report documents equal treatment, to include the use of blood from U.S. personnel, of enemy combatants at U.S. Army CSHs.

Conclusions

Fresh whole blood was used in the treatment of anemic, acidemic, hypothermic, coagulopathic patients with life-threatening traumatic injuries in hemorrhagic shock, and it was transfused in equal percentages and amounts for coalition soldiers, foreign nationals, and enemy combatants.

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